

## ANALYSIS OF ANOMALOUS CHARACTERS OF THE TIME-LATITUDE RESIDUALS OF YUNNAN OBSERVATORY BEFORE MAJOR EARTHQUAKES

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### I. INTRODUCTION

After the Tangshan earthquake in 1976, Chinese scholar discovered that before a strong earthquake, there appeared abnormal fluctuations in the residuals of astronomical time-latitude. A lot of analyses and researches for the residuals and the practice of the earthquake prediction have shown that the discovery is truthful. The abnormal fluctuation in time-latitude residuals is the reflection of changing's geophysical field during the pregnancy of a major earthquake, and contains a lot of geophysical information.

The astrolabe of Yunnan Observatory was installed in 1975 and began observation. Since then, over 20 years' observational data have been accumulated, the residuals of time-latitude have confirmed that its correlation with major earthquakes, and because of its good geographical position of yunnan observatory, the residuals have its own features of which it is special significance for the research of some geophysical phenomena. The aim of this paper is to analysis the twenty years' residuals of time-latitude of Yunnan observatory systematically, and to find some clue for the prediction of earthquakes.

### II. CALCULATION AND PROCESSING METHODS OF THE TIME-LATITUDE RESIDUALS

Different methods of calculation and processing are aimed at the extraction of different information and the key to whether forecast of an earthquake before it occurs is comparatively accurate or not lies in the optimization of the methods of calculation and analysis processing of the residuals. In this present article, the calculation and processing mainly cover the following aspects.

1. The initial calculation of the residual of time determination  $RT_i$ , and the residual of latitude determination  $RF_i$

$$RT_i = (UT1 - UTC)_i - (UT0 - UTC)_i - (X_i \sin \lambda - Y_i \cos \lambda) \tan \varphi / 15 \quad (1)$$

$$RF_i = \Delta\varphi_i - X_i \cos \lambda - Y_i \sin \lambda \quad (2)$$

where  $\Delta\varphi_i$  stands for the daily mean value of the determined values of the latitude variation in the observing day and,  $\lambda$  and  $\varphi$  for the adopted values of geographical coordinates of the photoelectric astrolabe at Yunnan Observatory.

2. The calculation five-day mean value and the zeroed mean value.

It is found from the comparison and analysis that the averaging time interval of 5 days is more advantageous to the preservation of the information of the warning signs of an earthquake than the averaging time intervals of 15 days or a month do, and therefore, the five-day weighted averages of  $RT_i$  and  $RF_i$  are respectively calculated and then the two sequences of  $RT_i$  and  $RF_i$  are respectively reduced to zero, i.e.

$$R_o = \frac{1}{N} \sum R_i \quad (3)$$

$$R_{oi} = R_i - R_o \quad (4)$$

3. Remove the annual and semiannual terms

In order to give prominence to the medium and short-term variation (anomaly), the annual and semiannual terms need to be filtered as the background. For the elimination of the annual terms, the epoch overlay method was previously adopted to filter them and later on, the harmonic analysis method of the 6-year average was used to calculate them. Now, the observational data of the same year are used to calculate the annual terms. For the sake of the earthquake forecasting, for those data of less than a year the data of a year from the deadline of them back to the same date of the last year are used to calculate the annual terms and semiannual terms, which can be effectively filtered by means of this method.

4. The five-point sliding average

In order to remove the short-term accidental disturbance the five-point weighted sliding average is take of which the formula for each sequence is as follows:

$$S_i = \frac{1}{9}(F_{i-2} + 2F_{i-1} + 3F_i + 2F_{i+1} + F_{i+2}) \quad (5)$$

Where F represents RT or RF.

5. The raise of the criterion of anomalies

According to the standard deviation formula

$$\sigma = \sqrt{\frac{\sum s^2 - \frac{(\sum s)^2}{N}}{N - 1}} \quad (6)$$

the standard deviations  $\sigma$  of the RT and RF sequences are respectively calculated and greater than or equal to  $2\sigma$ , or greater than or equal to  $3\sigma$  are respectively used as the warning indications of earthquakes.

### III. THE ANOMALOUS CHARACTERISTICS IN THE TIME-LATITUDE AT YUNNAN OBSERVATORY

Zhang Guodong et al. analysed the residual data of time-latitude of Beijing, Tianjing and Japan et al., S-shape double peak abnormal appeared in the time residuals and U-form single peak appeared in latitude residuals before major earthquake. According to above method we analyse in detail for our observations since 1976, and discover the abnormal characters in residuals of time-latitude at Yunnan observatory as follows:

1. A bigger single peak abnormal fluctuation appeared in the weighted mean values of five days for residuals of time-latitude major earthquake, however no S-form double peak abnormal appeared in time residuals, this may be related with the geological structure in Yunnan.

2. The abnormal fluctuation in residuals may correspond to a major earthquake in a larger area; or a middle and small earthquake in smaller area. The range can be 300-400 kilometer in diameter for 6 magnitude earthquake, for example, Menglian earthquake of April 24, 1984; and 500-700 KM for the 7 magnitude earthquake, for example, the earthquake at Mandalay of Burma on January 5, 1991.

3. The time of residuals anomaly takes about two months to half a year before earthquake, only Langcang earthquake on November 6, 1988, its residuals anomaly appeared 10 months before the earthquake, this is in agreement with other phenomena which discovered by seismic departments.

4. The anomaly of a remote great earthquake is simple, the contents of the anomalies of the great and major earthquake at near distance are quite rich and may be several times more than  $2\sigma$ , for example, the earthquake at Langcang in 1988.

5. The residuals fluctuation in the periods of seismic activity is obviously larger than in no seismic activity. For example, after the Puer earthquake on March 15, 1979, and before the Laizhou of Vietnam earthquake on January 24, 1983, this period was a quite calm in seismic activity, the curve of residuals of time-latitude was changing gently and no abnormal fluctuation appeared.

6. The asynchronization of residuals of time-latitude is the sign of no seismic activity, for example, in the end of 1986 and the second half of 1989, a bigger anomaly appeared in the latitude residuals, the time residuals was near anomaly but were asynchronous, so, no earthquake occurred.

We successfully provided the valuable information of the middle/short-term earthquake prediction for seven earthquakes in and around Yunnan by means of above the method and the anomalous characters, and take it effect in practice of earthquake prediction studies.

### IV. DISCUSSION

Zhang Guodong et al. analysed the relationship between the major earthquake and the residuals of time-latitude of Beijing, Tianjing and Japan et al., and discovered that double peak anomaly appeared in the time residuals but this phenomena did not appear in residuals of Yunnan observatory. This may be due to the different local structure. Yunnan is on the Mediterranean-Himalayas seismic belt, and on the famous cross mountains, near the connecting point of Asian-European and Indian plate. According to researches done by Kan Rongju, the Yunnan area is the most likely place for fastest relative tectonic movement in the Chinese continent. The feature decides the strong, frequent and short period of seismic activities in Yunnan. The seismic activities are shown in residuals of time-latitude. The time-latitude residuals as the warning sign of earthquake activities are dependable and accurate, and therefore, can be taken as a method for earthquake forecast. But there is some limitation to this method, because the astronomical observation can be only carried out at clear night, and dry and damp season are formed by the Yunnan's climate. The rainy and cloudy in Kunming from June to October. This can influence the continuity of the residuals of time-latitude. As a precursor, the residuals of time-latitude can give the prediction of earthquake activity in certain area and period of time, it is difficult to give precise location and time. A further study on these is needed to make the time-latitude residuals as an effective method for the earthquake prediction.

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